PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : D01G 1/08, 13/00, D02G 3/22

A1

(11) International Publication Number: WO 89/ 01999

(43) International Publication Date: 9 March 1989 (09.03.89)

(21) International Application Number: PCT/US87/02156

(22) International Filing Date: 26 August 1987 (26.08.87)

(71) Applicant (*for all designated States except US*): HELTRA INCORPORATED [US/US]; Route 903, Jim Thorpe, PA 18229 (US).

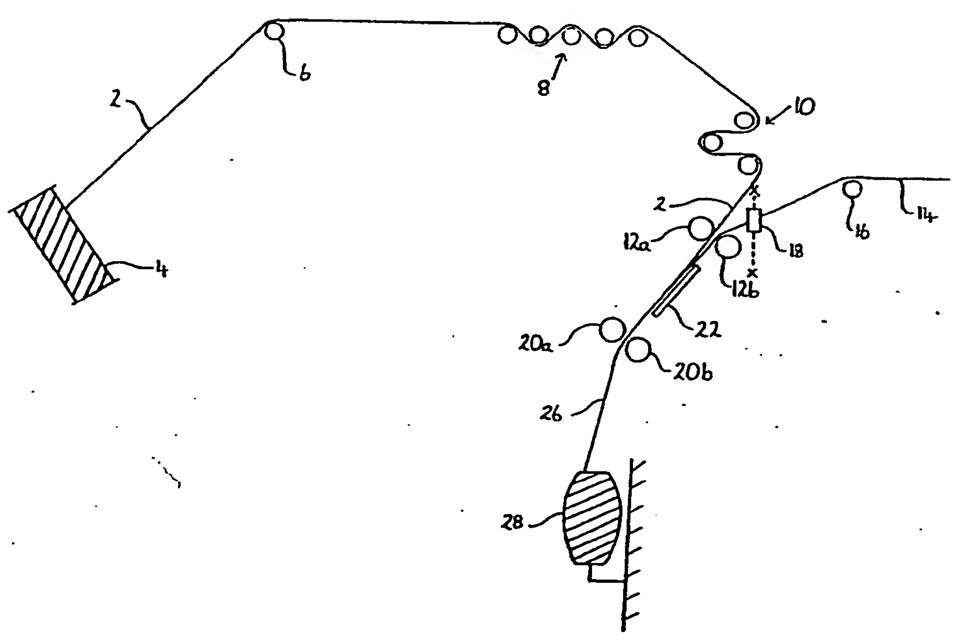
(72) Inventors; and
(75) Inventors/Applicants (*for US only*) : TRADEWELL, Kirk, Leon [US/US]; 130-C Hillcrest Road, Quakertown, PA 18229 (US). TRADEWELL, George, Edward [US/US]; HCR 1E Box 38, White Haven, PA 18229 (US).

(74) Agents: WEBER, Richard, D. et al.; Synnestvedt & Lechner, Suite 2600, 1101 Market Street, Philadelphia, PA 19107 (US).

(81) Designated States: AT (European patent), AU, BB, BE (European patent), BG, BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC, MG, MW, NL (European patent), NO, RO, SD, SE (European patent), SU, US.

Published
With international search report.

(54) Title: HYBRID YARN



(57) Abstract

A method for the manufacture of a hybrid yarn (26) which uses a stretch-breaking process to blend two or more different types of fibre, one of which is a reinforcing fibre. The fibre tows (2, 14), for example a tow of carbone filaments and a tow of thermoplastic filaments, are fed together into the stretch-breaking zone (at 22), broken by stretching between two pairs of nip rollers (12a, 12b: 20a, 20b), drafted and then processed into a yarn (26). Thus well-blended hybrid yarns are produced which can be of a variety of deniers, including low deniers. The yarns can be used in the formation of composite products.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
BB	Barbados	GB	United Kingdom	MW	Malawi
BE	Belgium	HU	Hungary	NL	Netherlands
BG	Bulgaria	IT	Italy	NO	Norway
BJ	Benin	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	LI	Liechtenstein	SN	Senegal
CH	Switzerland	LK	Sri Lanka	SU	Soviet Union
CM	Cameroon	LU	Luxembourg	TD	Chad
DE	Germany, Federal Republic of	MC	Monaco	TG	Togo
DK	Denmark	MG	Madagascar	US	United States of America
FI	Finland				

Hybrid Yarn

Technical Field

This invention relates to hybrid yarns comprising a blend of two or more different fibres one of which comprises reinforcing fibre.

It is well known that reinforcing material, such as carbon fibre, and a matrix material, such as a resin, can be combined to form composite products. These composites are usually manufactured by compounding the resin with staple carbon fibre in an extrusion compounder.

Discussion of Prior Art

As an alternative, fabrics have been produced. Usually the carbon fibre and resin are incorporated as separate components. For example the carbon fibre may be woven into a fabric which is then impregnated with resin to form a prepreg. In another example both carbon fibre and thermoplastic fibre may be woven together into a fabric, the carbon fibre being the weft, for example, and the thermoplastic fibre the warp. Both these constructions have the disadvantage that the two components are not in an intimate mixture and when they are consolidated into a fabric there exists discrete regions of carbon fibre and thermoplastic matrix.

Hybrid yarns have been suggested; for example UK Patent 2 105 247 B describes a yarn consisting of a core of carbon fibre wrapped with thermoplastic fibre, and NASA report number NASA-CR-3849 NASA1 26:3849 by M.E. Ketterer describes a hybrid yarn produced by intimately intermixing a tow of continuous carbon filaments with a tow of continuous thermoplastic filaments. Although these hybrid yarns may to some extent overcome the problem of inadequate mixing, they have the added disadvantage that the yarns, being a combination of two tows, are bulky.

Summary of the Invention

The present invention provides a method for the manufacture of a hybrid yarn which includes the step of blending two or more types of fibre, at least one of which

comprises reinforcing fibre, using a stretch-breaking process.

Preferably the method according to the invention is used to blend two types of fibre, especially reinforcing fibre, for example carbon fibre and matrix fibre, for example thermoplastic fibre. However, the method can also be used to blend two different reinforcing fibre types, such as carbon and glass fibre.

Stretch-breaking is a well-known technique for processing synthetic textile fibres such as acrylic fibre. We have found that if the process is adapted to enable a tow of reinforcing filaments, such as carbon, to be stretch-broken simultaneously with a tow of another fibre type such as matrix filaments, then a hybrid yarn comprising a well-blended mixture of the two fibre types can be produced. After being stretch-broken, the fibre can be drafted down to the desired yarn denier. Thus the process also has the advantage that hybrid yarns of low denier, for example 500 denier or less can be produced. Higher yarn deniers can, of course, also be produced.

Preferably the stretch-breaking process is carried out by the following method:-

(a) feeding at least two tows of continuous filaments, at least one tow comprising reinforcing filaments, through a first and second pair of nip rollers, one tow being superposed upon the others;

(b) setting the surface speed ratio of the first and second pairs of nip rollers so that the filaments are stretched and broken in the stretch-breaking zone between the pairs of nip rollers; and

(c) drafting the stretch-broken filaments and processing them into a yarn.

In commercially available stretch-breaking machines the tow is stretched almost to breaking point prior to being fed into the stretch-breaking zone by passing the tow through a series of nip rollers or through a heated zone. It is preferred not to use these methods when stretch-breaking carbon fibre because the fibre is susceptible to damage in the lateral direction and this prior stretching may result in a damaged, lower performance yarn. Instead, the carbon tow and thermoplastic tow are preferably fed directly from their packages into the stretch-breaking zone via the first pair of nip rollers, although some pre-tensioning that is relatively gentle may be included, for example by passing one or both of the tows through a series of pre-tensioning bars.

To facilitate spreading of one or both of the tows and to control lateral movement, a guide may be positioned in front of the first pair of nip rollers. The guide generally has a slit or indentation through which the tow or tows pass, the width of the slit or indentation being slightly wider than the width of the flattened, spread tow. A spread tow is preferred in order to avoid bunching of the filaments during stretch-breaking which leads to uneven drafting and inconsistent processing. If pre-tensioning bars are used then these aid in spreading out the tows and an additional guide may be omitted. Preferably the carbon tow is fed through a series of pre-tensioning bars and the thermoplastic tow is passed through a guide.

The two tows are preferably superposed upon each other prior to being fed through the first pair of nip rollers so that good mixing of the two fibres is achieved when they are broken and drafted.

The ratio of surface speeds of the first and second pairs of nip rollers must be set so that the filaments are

broken in the stretch-breaking zone. In addition the ratio is preferably set so that the fibres are drafted to the desired yarn denier. In general the second pair of nip rollers is set to have a surface speed of between 6 and 35 times faster than the first pair, preferably between 8 and 25 times faster.

When a tow of thermoplastic filaments is used, a restraining means is advantageously positioned in the stretch-breaking zone to prevent recoil of the more elastic thermoplastic filaments when they break. It has been found that recoil can be prevented by interposing the tow of the thermoplastic filaments between the carbon tow and the restraining means which is conveniently in the form of a plate, for example a metal plate. This method is beneficial as the carbon fibre does not have to come into contact with the restraining means which otherwise may damage the fibre. Preferably the restraining means is positioned below the thermoplastic tow so that it exerts a light upward supporting pressure on the thermoplastic filaments; and the tensioned carbon tow is above the thermoplastic tow so that it simultaneously exerts a slight downward pressure on the thermoplastic filaments.

The ratch, which is the distance between the first and second pairs of nip rollers, is preferably set at the maximum distance that is mechanically permitted. Typically this is 150mm to 250mm, although this distance may vary depending upon the machinery used. The longer ratch enables longer staple lengths to be obtained which gives a higher reinforcing strength in the resulting composite.

After being stretch-broken the fibres are drafted, condensed and passed through the second pair of nip rollers. The condensing is preferably aided by a condensing guide. Unlike commercial stretch-breaking processes, the process of the invention is advantageously a direct tow-to-yarn process, in which filaments are

stretch-broken and drafted to a yarn having the desired denier in one stage, ie it is a continuous process with no intermediate collection of a sliver. In commercial processes the tow is drafted to a sliver and then the sliver further drafted to a yarn as a separate stage. Although the latter technique can be used in the present process, it has the disadvantage that the carbon fibre is more likely to become damaged because of the greater number of processing steps. Thus after being stretch-broken the fibres are preferably drafted to the desired denier of the resulting hybrid yarn, usually between 100 and 1400 denier, frequently between 100 and 800 denier.

After passing through the second pair of nip rollers the fibres can be formed directly into a yarn as a continuous process by inserting a twist, for example using a ring and traveller system, and winding into a package.

Alternatively, for example instead of using a ring and traveller system the stretch-broken fibres can be passed through a hollow spindle and wrapped with another yarn, for example a thermoplastic fibre yarn such as a polyetherketone, eg polyetheretherketone (PEEK). This alternative method is advantageous when it is desired to produce a hybrid yarn without any twist in the carbon fibre component. It also allows a greater proportion of thermoplastic fibre to be incorporated into the yarn.

The present invention also includes a hybrid yarn comprising a blend of at least two different types of stretch-broken fibre, at least one of which comprises refinforcing fibre. Preferably the hybrid yarn comprises a blend of stretch-broken reinforcing fibre and stretch-broken matrix fibre, the latter preferably being thermoplastic fibre.

The proportion of reinforcing fibre to matrix fibre in the hybrid yarn depends upon the required end use of the fibre, but in general the proportion is between 55 to 99%, preferably 60 to 80%, reinforcing fibre and 45% to 1%, preferably 40 to 20%, matrix fibre by weight based on the total weight of the yarn.

Although the invention has been described above with reference mainly to carbon fibre as the reinforcing fibre and thermoplastic fibre as the matrix fibre, other reinforcing fibres and matrix fibres can be used. For example, other reinforcing fibres include glass fibre, aramid fibre, oxidised polyacrylonitrile fibre, multi-filament ceramic fibres, for example silicon carbide fibre and graphite-, plastics- or metal-coated carbon fibre. Examples of thermoplastics for the matrix fibre include polyketones such as a polyetherketone and polyetheretherketone (PEEK), polytetrafluoroethlyene, polyamides such as nylon, polyesters such as poly(ethylene terephthalate) and poly-(butylene terephthalate), polyimides such as polyetherimide, polyolefins such as polyethylene, polypropylene and copolymers of ethylene and propylene and, polysul- phones such as polyethersulphone.

The hybrid yarn may be assembled in a variety of ways prior to consolidating into a composite wherein the matrix fibre component is fused to surround and embed the reinforcing fibre component. For example the yarn may be assembled into bundles, warps, arrays or windings. However, for ease of handling and flexibility of design of the composite structure, the yarn is preferably assembled into fibrous fabric form. The fibrous fabric may be a woven, knitted, braided, non-woven or pile fabric. The ability of the method of the invention to produce low denier yarns enables highly drapable fabrics to be formed which facilitate the formation of shaped composite

products. The present invention includes fabrics and composite products formed from the hybrid yarn.

Brief Description of Drawing

The invention will now be described, by way of example only, with reference to the accompanying drawing, in which:-

Figure 1 shows, diagrammatically, a process for manufacture of a hybrid yarn using stretch-breaking; and

Figure 2 is a cross-sectional view along the line X-X of the guide used in the process shown in Figure 1.

Description of Preferred Embodiment

A 12,000 filament, 7320 denier carbon fibre tow 2 is unwound from a package 4 and fed via a guiding roller 6 through a cascade of rollers 8. This cascade 8 pre-tensions the carbon fibre and spreads it out to a substantially flat tow. After passing through further guiding rollers 10, the tow 2 is fed through a first pair of nip rollers 12a and 12b. Both the rollers have a smooth surface, the upper roller 12a having a synthetic rubber surface and the lower roller 12b a steel surface.

A 900 filament, 3800 denier PEEK fibre tow 14 (PEEK fibre is available from Celanese Corporation) is unwound from a package (not shown) and fed, via a guiding roller 16, through the nip rollers 12a and 12b, the thermoplastic tow being fed underneath the carbon tow 2. Prior to passing through the nip rollers 12a and 12b, the thermoplastic tow 14 travels over a guide 18. Referring to Figure 2, this guide 18 consists of an aluminium block 100 into which is cut a 9.5 mm wide groove 102. The tow 14 is passed over the groove 102 which is just wide enough to allow the tow 14 to spread to a flat tow without creating voids between the filaments.

After passing through the first pair of nip rollers 12a and 12b, the tows 2 and 14 enter the stretch-breaking

zone which is the zone between the first pair of nip rollers 12a and 12b and a second pair of nip rollers 20a and 20b. The ratio of surface speeds between the first and second pairs of nip rollers is set at 1:8, and the ratch distance is 200 mm.

The tows 2 and 14 are fed from the first pair of nip rollers 12a and 12b through the second pair of nip rollers 20a and 20b. Again both rollers have smooth surfaces, the upper roller 20a having a synthetic rubber surface and the lower roller 20b a steel surface. The faster speed of the second pair of nip rollers causes the filaments in both tows to stretch and break in the stretch-breaking zone.

Because of the elastic nature of the thermoplastic filaments, they tend to recoil when stretch-broken. To prevent this a restraining means which consists of a rectangular aluminium plate 22 is positioned under the thermoplastic tow 14 in the middle of the stretch-breaking zone where the breaking of the filaments occurs. Because the carbon tow 2 is superposed above the thermoplastic tow 14, the thermoplastic tow is sandwiched between the carbon tow 2 and the plate 22, and the combination of forces exerted on the thermoplastic tow 14 by the carbon tow 2 and the plate 22 prevents recoil of the thermoplastic filaments when they break.

After breaking, the filaments are drafted, with the aid of a 3.2mm wide condenser guide (not shown), directly to a 200 denier yarn by the second pair of nip rollers 20a and 20b. The condenser guide is pivotally fixed in the stretch-breaking zone to allow lateral movement of the tows which facilitates the passage of the tows through the stretch-breaking zone. The combination of stretch-breaking and drafting thoroughly mixes the carbon fibre with the thermoplastic fibre. After drafting, twist is inserted in the yarn using a conventional ring and traveller system (not shown) and the resulting multi-

filament hybrid yarn 26 is collected on a bobbin 28. The proportion of carbon and PEEK fibre in the resulting yarn is 65% carbon fibre and 35% PEEK fibre by weight based on the total weight of the yarn.

To facilitate start-up of the process, stretch-breaking of the carbon fibre tow 2 may be initiated before the thermoplastic tow 14 is fed through the nip rollers 12a and 12b.

CLAIMS

1. A method for the manufacture of a hybrid yarn which includes the step of blending two or more different types of fibre, at least one of which comprises reinforcing fibre, using a stretch-breaking process.

2. A method according to claim 1, wherein two tows are blended together using the stretch-breaking process, one tow comprising reinforcing filaments and the other tow comprising matrix filaments.

3. A method according to claim 2 which comprises:-

(a) feeding at least two tows of continuous filaments, at least one tow comprising reinforcing filaments, through a first and a second pair of nip rollers, one tow being superposed upon the other;

(b) setting the surface speed ratio of the first and second pairs of nip rollers so that the filaments are stretched and broken between the pairs of nip rollers; and

(c) drafting the stretch-broken filaments and processing them into a yarn.

4. A method according to claim 3, which is a direct tow-to-yarn process, the filaments being stretch-broken and drafted to the desired yarn denier in one stage.

5. A method according to claim 4, wherein a restraining means is positioned between the first and second pairs of nip rollers to prevent recoil of the matrix filaments when they are stretch-broken.

6. A method according to claim 5, wherein the restraining means comprises a plate which is positioned such that the tow of matrix filaments is interposed between the tow of reinforcing filaments and the plate, recoil of the matrix filaments on breaking being prevented

by the forces exerted on the matrix filaments by the reinforcing filaments and the plate.

7. A hybrid yarn comprising a blend of different types of stretch-broken fibre, at least one type of fibre comprising reinforcing fibre.

8. A yarn according to claim 7 which comprises a blend of stretch-broken reinforcing fibre and stretch-broken matrix fibre.

9. A yarn according to claim 7 wherein the reinforcing fibre is made up of carbon filaments.

10. A yarn according to claim 8, wherein the matrix fibre is made up of a thermoplastic, preferably a polyetherketone.

11. A yarn according to claim 8 which has a denier of between 100 and 1400, preferably between 100 and 800.

12. A yarn according to claim 8 wherein the proportion of reinforcing fibre and matrix fibre is 55 to 99% reinforcing fibre and 45 to 1% matrix fibre.

13. A fabric at least partly formed from the yarn according to claim 7.

14. A composite product formed from the yarn according to claim 7 or from the fabric according to claim 13.

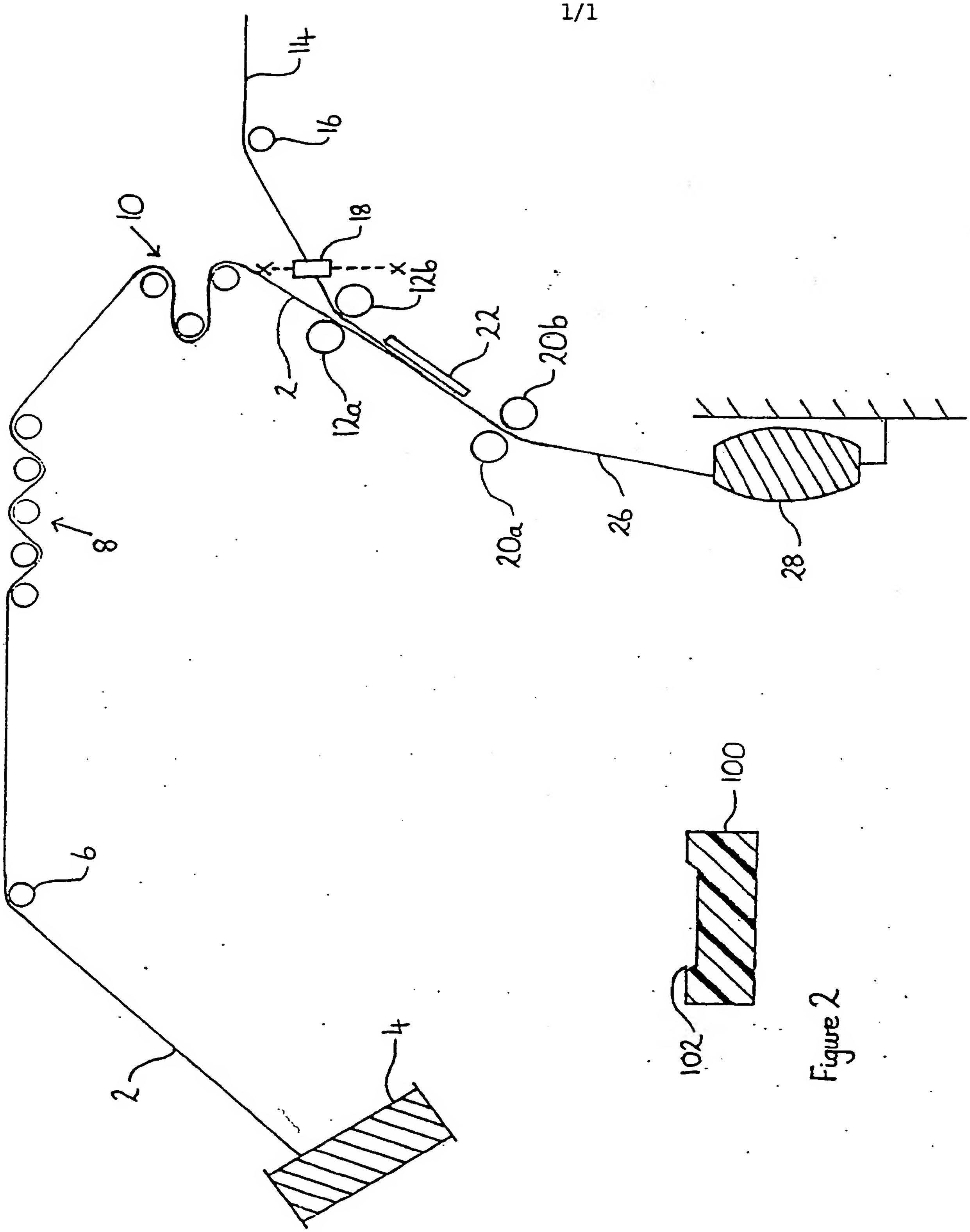


Figure 1

Figure 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 87/02156

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: D 01 G 1/08; D 01 G 13/00; D 02 G 3/22

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC^4	D 01 G; D 01 H; D 02 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	AU, B, 476167 (BRUNSWICK CORP.) 24 October 1974, see pages 8,10; figures 2,3; claims 1,2	1,2
A		4,7,8,13
A	GB, A, 2084977 (THE SECRETARY OF STATE FOR DEFENCE) 21 April 1982, see front-page; page 1, lines 15-19,28-37,53-56,106-113; page 2, lines 4-21; claims 5,6,8	1,7,8,9,13
A	US, A, 4369622 (R.K. TEED et al.) 25 January 1983, see front-page; column 2, lines 61-68; column 3, lines 1-7,23-50; column 4, lines 24-57; column 7, lines 53-57; figures 1,4	1,7,8,13
A	US, A, 2262872 (W. WHITEHEAD) 18 November 1941	

* Special categories of cited documents:[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26th May 1988	05 JUIN 1988
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8702156
SA 20955

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 20/06/88
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
AU-B- 476167	24-10-74	AU-A- 7196274	24-10-74
GB-A- 2084977	21-04-82	JP-A- 57042927 DE-A- 3107343 US-A- 4461855	10-03-82 15-04-82 24-07-84
US-A- 4369622	25-01-83	None	
US-A- 2262872		None	

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82